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## ABSTRACT

This paper criticizes Zajonc's confluence model of the relationship between sibling spacing and sibling intelligence. According to Zajonc, variations in the intellectual performance of individuals are accounted for in part by two features of the individual's family of orientation: (1) the number of children in that family, and (2) the spacing between those children in a family. This model is criticized for (1) inconsistencies in the relationship between child spacing and intelligence in the data reported in Zajonc's paper; (2) the failure to present previous child spacing-intelligence data which conflict with the confluence model and (3) the problem of using between-family data for making within-family inferences about intelligence. New within-family data are presented which indicate that there is essentially a zero relationship between child spacing and academic achievement.  
(Author/BH)

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Sibling Spacing and Academic Achievement:

A Within-family Perspective

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Abstract

Zajonc presented evidence which appeared to substantiate a positive relationship between sibling spacing and sibling intelligence. A closer look at his paper revealed three major weaknesses: spacing data did not match intelligence data, conflicting spacing-intelligence data were absent, and between-family data were used in making within-family inferences. New within-family data show essentially a zero relationship between spacing and academic achievement.

The empirical relationships between family size (FS), birth order position (BOP), and intellectual development have not been clearly established in spite of several previous empirical and theoretical studies. Negative, neutral, or positive relationships have all been reported between FS (1-3) and intellectual development and between BOP (4-6) and intellectual development. As a result, attempts to reconcile the effects of these family configuration variables on intellectual development have been received with reservation.

In 1975, Zajonc and Markus presented a theoretical model which appeared to resolve many of the previous inconsistencies of the family configuration-intellectual development data (7). According to their model, called the confluence model, variations in the intellectual performance of individuals are accounted for in part by two features of the individual's family of orientation: 1) the number of children in that family, and 2) the spacing between those children (child spacing = CS). The basic assumption of the confluence model is that the intellectual level of an individual is a cumulative function of the average intellectual environment (AIE) to which he/she has been exposed in his/her family. At any point in time ( $t$ ) the AIE of the family is determined by the following equation:

$$AIE_t = \frac{\sum \text{Intellectual levels of family members } t}{\text{Number of family members } t} \quad (8)$$

Increasing FS is hypothesized to decrease the AIE since additional newborns add an intellectual level of zero to the numerator and one to

the denominator. Increasing the CS between siblings is assumed to increase the AIE since longer spacings allow for greater intellectual growth for existing siblings thus increasing only the numerator. Birth order position is not a functional variable in the confluence model as BOP effects are assumed to be mediated totally by CS. A second-born in a two-child family can enter an AIE that is either lower  $\left[ (30 + 30 + 4 + 0)/4 = 16 \right]$  or higher  $\left[ (30 + 30 + 24 + 0)/4 = 21 \right]$  than the AIE entered by the first-born at birth  $\left[ (30 + 30 + 0)/3 = 20 \right]$  depending on whether the second-born was spaced close or far, respectively.(9)

Four national data sets dealing with FS, BOP, and intelligence have been presented subsequently by Zajonc (10) as being consistent with predictions derivable from the confluence model when adjustments for national differences in CS were made. The present report focuses on the use (misuse) of the CS parameter by Zajonc (10). Three main issues are discussed: 1) inconsistencies in the relationship between CS and intelligence in the data of Zajonc's paper, 2) the failure to present previous CS-intelligence data that conflict with the confluence model, and 3) the problem of using between-family data for making within-family inferences about intelligence. Finally, new data collected from a within-family sample will be used to estimate the effects of family size, child spacing, and birth order position on intellectual achievement when controlling for other relevant variables.

Zajonc considered intellectual performance scores by FS and BOP for Dutch, American, French, and Scottish samples [see Zajonc (10, Fig. 1)]. In all four samples, intellectual performance declined regularly with increasing FS. The relationship of intellectual performance and BOP, however, was not as consistent. The Dutch and American samples showed

declining intellectual performance for later sibs, the Scottish sample showed negligible BOP effects, and the French sample showed increasing intellectual performance for later sibs. Since BOP effects are assumed to be mediated entirely by CS these different relationships between intellectual performance and BOP must be attributed to different CS patterns in the four samples.

Zajonc computed two measures of CS to support this point: the crude birthrates of the four countries and the national average for intervals between births in completed French families. The national crude birthrate proved to be greater for the Dutch and American samples than for the French and Scottish samples. Zajonc concluded that the average CS was closer in the former than in the latter two samples and that the differing national BOP effects were consistent with predictions from the confluence model. It should be pointed out that the crude birthrate is demographically unsound as a measure of child spacing. The crude birthrate may reflect changes in spacing of first births after marriage, changes in marriage patterns, or merely changes in the age structure of the population, none of which reflect sibling spacing or are otherwise relevant to the confluence model.

The second measure--average birth intervals between successive births in the French population--contradicts several aspects of the French intelligence data. While it is true that within each FS the average spacing between French children increases with increasing BOP, it is also clear that the absolute levels of spacing decrease with increasing FS [see Zajonc (10, Fig. 3)]. Furthermore, differences between the spacing of earlier and later children decrease with increasing FS. These latter two facts

lead to the prediction that the effect of BOP on intellectual performance should decrease with increasing FS. However, Figure 1, Panel 3 of Zajonc (10) shows the BOP effects to be increasing positively with increasing FS in the French IQ data.

The French IQ data pose three additional problems for the confluence model. First, all of the observed spacings in Figure 3 of Zajonc (10) are well below the minimum CS required by the confluence model for obtaining successively brighter sibs. In the simple case of a superior secondborn in FS 2  $\left[ (30 + 30 + 24 + 0) / 4 = 21 \right]$ , the confluence model requires a spacing interval of approximately 16 years (11, 12). The average spacings for BOP 2 in Figure 3 of Zajonc (10) are all less than 6 years. Extensions of this analysis to BOP 3 or more result in the same outcome: the obtained average spacings of French children are far less than those expected by the confluence model for successively brighter sibs (13).

Second, the condition of successively brighter siblings in FSs 3 or more is rendered infeasible due to the excessive spacing requirements of the confluence model. For example, the spacing necessary for a superior thirdborn in FS 3 places the CA of the secondborn at 13.33, the CA of the firstborn at 29.33 (see Footnote 13). Most parents would have passed the end of their childbearing years before a third child could be spaced in this manner. In addition, the firstborn would likely have left home before CA 29.33, and the thirdborn would really then be entering an AIE of 20  $\left[ (30 + 30 + 20 + 0) / 4 \right]$ . This simple example can be extended to increasingly larger FSs with the same result: the factors of infertility and mature sibs leaving home seriously preclude the confluence model from handling data where the intellectual attainment rises with increasing BOP beyond FS 2 as observed in the French IQ data.

Third, the confluence model cannot account for intellectual performance data where the directions of the FS and BOP effects differ. This is due to the model's assumption that BOP and FS effects are both directly related to AIE changes between births. If families increase their AIE between successive births (positive FS effect), BOP effects will be positive. If family AIE decreases between births, BOP effects will follow suit. Table 1 depicts these two outcomes plus neutral FS-BOP effects (14). The rub for the confluence model comes when it has to account for negative FS effects in samples where the effects of BOP are either neutral (Scottish) or positive (French). In order for the FS predictions to be consistent with the obtained BOP effects, the confluence model would have to predict positive (Table 1, Column 3) and neutral FS effects (Table 1, Column 2) for the French and Scottish Data, respectively. Panels 3 and 4 of Zajonc's Figure 1 (10) show negative FS effects in both cases.

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 Insert Table 1 about here  
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The confluence model prediction of increasing intellectual performance with increasing CS intervals has been contradicted by at least three published studies. Koch (15) investigated the relationship of sibling spacing with intellectual skills using the Thurstone Primary Mental Abilities Test (TMPAT) with 360 five- to six-year-old children from two-child families. Her data indicated a quadratic [ $F(1, 322) = 2.77, p < .10$ ], but not a linear ( $F < 1$ ) relationship between spacing and total score on the TMPAT ( $\bar{X} = 108.79, 111.42, 108.83$  for 7-24, 25-48, and 49-72 months spacing, respectively). (16)

Rees and Palmer (17) reanalyzed the data of five longitudinal studies

(the Fels Longitudinal Study, the Berkeley Growth Study, the Berkeley Guidance Study, the Oakland Growth Study, and the investigation conducted by the Child Research Council of The University of Colorado School of Medicine in Denver) and found no consistent relationship between sibling spacing and intelligence. In their report, correlations were computed on the Stanford-Binet IQ and Wechsler-Bellvue Intelligence scores with the spacing to the next older and next younger sibling. Their findings showed small and inconsistent effects of spacing to either sibling on intelligence scores, the correlations fluctuating around zero.

Breland (4) presented spacing data collected from nearly 800,000 eleventh-grade students taking the National Merit Scholarship Qualification Test (NMSQT) in 1965. His data showed that across two- and three-child families it made essentially no difference for a first child whether the spacing to its sib(s) was short (two years or less) rather than long (three years or more). In addition, only the last child in FS 2 and 3 showed any appreciable negative effect due to short spacing. The small negative effect on the secondborns disappeared across FS 2 to 3. Both the negligible effects of spacing on the firstborn and the transitory nature of the spacing effect on the secondborn across FS 2 and 3 are incongruent with predictions from the confluence model.

A further elementary, but very serious problem exists with the national data sets presented by Zajonc (10). Valid inferences regarding sibling differences in intellectual development cannot be reliably made from between-family samples. Past studies using both between- and within-family comparisons have shown that opposite conclusions can be reached regarding intellectual performance depending on the approach taken.

Thurstone and Jenkins (6) used both procedures and found that Stanford-Binet IQ scores decreased with BOP (here confounded with FS) when viewed between families. However, when IQ was studied within families, the trend was reversed with laterborn children scoring higher on the Stanford-Binet. Record, McKeown, and Edwards (5) analyzed verbal reasoning (VR) scores of 48,913 children born in Birmingham, England between the years 1950-1954. Record et al.'s between-family analysis showed a marked negative relationship between BOP and VR while their within-family analysis, based on 5,054 sibling pairs, showed essentially no relationship between BOP and VR. According to Record et al., "The conclusion which emerges from the sib comparison is that differences between mean V.R. scores of sibs are small and that the striking association of measured intelligence with maternal age and birth order observed in a general population of births (Fig. 1) is determined mainly by differences between rather than within families (p. 65)." Thus the between-family data used by Zajonc for inferring the relationship of within-family variables (BOP, CS) may be invalid for testing the confluence model's predictions for within-family differences in intellectual levels.

In 1975 we collected data on family configuration and intellectual achievement from over 5,000 sibling pairs of whom one sibling was attending B.Y.U. in the fall of 1975. In 1,200 of these pairs ACT scores for both sibs and additional family information (mother's and father's education, father's occupation) were available through University records. The difference between sib ACT scores (younger sib ACT - older sib ACT) was specified as the dependent measure. The confluence model predicts that this difference would be negative at short spacings and zero or positive at longer spacings.<sup>18</sup> Our sample means for sib ACT difference scores at 12 mo. spacing intervals (0 to 12 months, 13 to 24

months, etc.) were negative at short spacings and did not monotonically become more positive with increased spacing as predicted by confluence theory:  $\bar{X}$  (ST, N) = -.66 (4.44, 53), -1.17 (5.03, 440), -1.08 (5.45, 268), -2.47 (4.41, 131), -2.24 (5.44, 127), -1.95 (5.57, 63), -3.34 (4.10, 50). Rather, these means became slightly more negative with increased spacing, the trend being nonlinear,  $r = -.025$ . Table 2 presents the regression results of CS on sib ACT score difference controlling for a number of family configuration and environmental variables (19). It can be seen in Table 2 that the simple correlation of  $-.025$  between CS and sib ACT score difference becomes a standardized slope ( $\beta$ ) of  $.0192$  when other variables are controlled through regression analysis. This statistically insignificant change in the amount and direction of the effect of CS on sib ACT differences indicates that the explained variance attributed to CS with or without additional control variables is negligible. The unstandardized regression coefficient ( $B$ ) for CS is  $.0040$ , which when translated into practical terms means that a family would have to space two sibs 250 months (20.83 years) apart in order to reduce their ACT score difference by one point, all other variables in the regression remaining constant. Thus the present within-family data do not support the notion that increasing CS significantly enhances the ACT scores of younger sibs relative to older sibs within a reasonable time span.

Table 2 also indicates that increasing mother's education and/or improving father's occupation (SES?) tends to reduce the difference among sibling ACT scores. The variable of older sib ACT score likely reflects a scaling artifact due to the attenuation of potential positive difference scores when performance of the older sib approaches ceiling.

One may question the generality of the present CS results due to the selectivity of the sample (Mormon college students). Indeed, one could argue

that cultural, religious, or social covariates accounted for the obtained CS - intellectual performance relationship (20, 21). It should be recognized, however, that such an argument presupposes parameters not yet included in the confluence model.

In conclusion, the confluence model does not handle well the child spacing-intellectual achievement relationship in either the four national data sets of Zajonc (10) or several other published reports. In addition, the past use of between-family data for testing the confluence model may not have been appropriate. Finally, our within-family data showed essentially a zero relationship between CS and intellectual development.

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2. P. R. Kunz and E. T. Peterson, Soc. Biol. **20**, 454 (1973).
3. E. W. Reed, Soc. Biol. **18** (Suppl.), S42 (1971).
4. H. M. Breland, Child Dev. **45**, 1011 (1974).
5. R. G. Record, T. McKeown, J. H. Edwards, Ann. Hum. Genet. **33**, 61 (1969).
6. L. L. Thurstone and R. L. Jenkins, J. Educ. Psychol. **20**, 641 (1929).
7. R. B. Zajonc and G. B. Markus, Psychol. Rev. **82**, 74 (1975).
8. For simplicity of discussion we shall deal with AIE only at birth.  
A description of the confluence model's predictions over the developmental span of birth to intellectual maturity is presented in Zajonc and Markus (7, p. 77ff).
9. In this and the following examples we will assume, along with Zajonc (10), the absolute intellectual level of each parent to be 30 arbitrary units.
10. R. B. Zajonc, Science **192**, 227 (1976).
11. We are assuming for mathematical simplicity that adult mental maturity (30 units) is reached at chronological age (CA) 20, hence 24 units (80% adult MA) would be assumed to be reached at roughly CA 16 (80% adult CA). A sigmoid--as proposed by Zajonc and Markus (7)--instead of a linear relationship between CA and intellectual development would not change markedly the CA at which a particular intellectual level is reached for this example.
12. The use of other base values for adult intellectual maturity does not alter the substantive issue of this example. If one assumes 100 units as the base level for adult intellectual maturity, then the

firstborn must achieve 72% of its adult intelligence before a second-born can enter an AIE superior (68) to that of the firstborn's AIE at birth (67). The level of 72 units would be achieved at approximately CA 14.4.

13. Assuming all siblings asymptote at 30 mental units and remain at home during the childrearing years, the following values (based on AIE at birth) represent the minimum spacing in years required by the confluence model for each successively brighter sibling: 16, 13.33, 12, 12, 13.33, 16, and 20 for BOP 2-8, respectively. The logic and calculations for BOP 3 and 4 are as follows:

$$\begin{array}{lcl} \text{AIE} & = & (30 + 30 + 30 + 20 + 0)/5 = 22, \text{ BOP 2} = 20 \text{ units,} \\ \text{BOP3} & & \text{MA} \end{array}$$

$$\begin{array}{lcl} \text{BOP 2} & = & 13.33 \text{ years, hence CS} = 13.33 \text{ years.} \\ \text{CA} & & \text{BOP3} \end{array}$$

$$\begin{array}{lcl} \text{AIE} & = & (30 + 30 + 30 + 30 + 18 + 0)/6 = 23, \text{ BOP 3} = 18 \text{ units,} \\ \text{BOP4} & & \text{MA} \end{array}$$

$$\begin{array}{lcl} \text{BOP 3} & = & 12 \text{ years, hence CS} = 12 \text{ years.} \\ \text{CA} & & \text{BOP4} \end{array}$$

14. Figure 4 of Zajonc and Markus (7) displays graphically this BOP-FS covariation for a four-child family. The upper panel portrays decreasing intellectual attainment with BOP under conditions of close spacing (negative BOP effect), the lower panel depicts increasing intellectual attainment with BOP with far spacing (positive BOP effect). In the upper panel, AIE decreases regularly between sibs (negative FS effect) while in the lower panel AIE increases consistently between sibs (positive FS effect) and eventually achieves a level higher than the final AIE level in the upper panel.

15. H. L. Koch, Child Dev. 25, 209 (1954).
16. Koch's data also lend themselves to testing Zajonc and Markus' predicted CS by BOP interaction in a two-child family. According to Zajonc and Markus (7, p. 85), increasing CS should raise the intellectual attainment of a secondborn due to an improved intellectual milieu but lower the intellectual level attained by a firstborn due to fewer opportunities to be a teacher to its younger sib. The Koch data showed no such CS by BOP interaction,  $F < 1$ . The previously mentioned quadratic relationship between spacing and the TMPAT was consistent for both first and secondborns.
17. A. H. Rees and F. H. Palmer, Develop. Psychol. Monogr. 3, 40 (1970).
18. See Figure 4 of Zajonc and Markus (7).
19. The younger sib's year of birth was included as a control for the national decline in ACT scores in previous years. The older sib's ACT score was included to control for scaling problems associated with difference scores on a restricted scale. The higher an older sib's ACT score, the less likely a positive difference score (younger-older) can occur.
20. D. J. Davis, S. Cahan, J. Bashi, Science 196, 1470 (1977).
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22. This research was funded by grants from the Brigham Young University Research Division and the Family Research Institute. We thank Darwin Thomas, Phillip Kunz, Leo Vernon, Jeffrey Holland, and Hugh Nibley for their assistance with this project.

Table 1

Average intellectual environment for successive siblings  
under close, moderately far, and far spacing conditions.

|        |                                        | Close                                | Moderately<br>Far                      | Far                                    |
|--------|----------------------------------------|--------------------------------------|----------------------------------------|----------------------------------------|
| FS = 1 | Sibling #1                             | $\frac{30 + 30 + 0}{3} = 20$         | $\frac{30 + 30 + 0}{3} = 20$           | $\frac{30 + 30 + 0}{3} = 20$           |
| FS = 2 | Sibling #1<br>Sibling #2               | $\frac{30 + 30 + 4 + 0}{4} = 16$     | $\frac{30 + 30 + 20 + 0}{4} = 20$      | $\frac{30 + 30 + 24 + 0}{4} = 21$      |
| FS = 3 | Sibling #1<br>Sibling #2<br>Sibling #3 | $\frac{30 + 30 + 7 + 3 + 0}{5} = 14$ | $\frac{30 + 30 + 30 + 10 + 0}{5} = 20$ | $\frac{30 + 30 + 30 + 20 + 0}{5} = 22$ |

Table 2  
Regression Analysis of Sibling ACT score differences

| Dependent Variable                                                                    | $\bar{X}$ | SD      | $B^{(1)}$ | $\beta^{(2)}$ | SE <sup>(3)</sup> |
|---------------------------------------------------------------------------------------|-----------|---------|-----------|---------------|-------------------|
| ACT score difference<br>(younger sib ACT - older sib ACT)                             | -1.4417   | 5.1493  | ---       | ---           | ---               |
| Independent Variables                                                                 |           |         |           |               |                   |
| 1. Younger sib's birth year                                                           | 1955.6842 | 1.4829  | -.0923    | -.0266        | .0847             |
| 2. Older sib's ACT score                                                              | 24.2083   | 4.3882  | -.6629*   | -.5649        | .0292             |
| 3. Father's occupation<br>(10 point scale, 1=professional)                            | 2.4533    | 2.0968  | -.2047*   | -.0833        | .0731             |
| 4. Father's education<br>(10 point scale, 10=high)                                    | 6.5408    | 1.5834  | .0339     | .0104         | .1047             |
| 5. Mother's education<br>(10 point scale, 10=high)                                    | 5.3825    | 1.3333  | .2752*    | .0713         | .1026             |
| 6. Family size<br>(number of children in family)                                      | 5.2133    | 1.8227  | .0882     | .0312         | .0765             |
| 7. Younger sib's BOP<br>(1=first born, 2=second, etc.)                                | 2.7325    | 1.0337  | -.4797    | -.0963        | .2619             |
| 8. Number of intervening sibs<br>(number of sibs born between older and younger sibs) | 1.6683    | 1.1012  | .0007     | .0001         | .2260             |
| 9. Spacing<br>(CA difference between older and younger sibs in months)                | 36.8067   | 25.0827 | .0040     | .0192         | .0063             |

Constant = 19.2488,  $R^2 = .3058^*$ ,  $N = 1200$ ,  $F(9, 1190) = 58.24^*$  ( $MS_e = 18.5470$ ),  $* = p < .05$

<sup>1</sup> $B$  = unstandardized regression coefficient, <sup>2</sup> $\beta$  = standardized regression coefficient, <sup>3</sup>SE = standard error of regression coefficient

Table 2 (cont.'d)

Intercorrelations of Independent and Dependent Variables

|           |        |        |        |        |        |        |        |        |        |    |
|-----------|--------|--------|--------|--------|--------|--------|--------|--------|--------|----|
| 1.        | --     |        |        |        |        |        |        |        |        |    |
| 2.        | .0067  | --     |        |        |        |        |        |        |        |    |
| 3.        | -.0580 | -.1657 | --     |        |        |        |        |        |        |    |
| 4.        | .1002  | .1845  | -.5794 | --     |        |        |        |        |        |    |
| 5.        | .0464  | .1795  | -.2154 | .3946  | --     |        |        |        |        |    |
| 6.        | .0250  | .0539  | -.0214 | .0964  | -.0110 | --     |        |        |        |    |
| 7.        | .0804  | -.0537 | .0806  | -.1322 | -.0806 | .3517  | --     |        |        |    |
| 8.        | .0620  | -.0337 | .0905  | -.1324 | -.0669 | .3473  | .8642  | --     |        |    |
| 9.        | .0472  | -.0389 | .0808  | -.1221 | -.0285 | .0226  | .5812  | .4920  | --     |    |
| (dep) 10. | -.0272 | -.5305 | -.0164 | -.0067 | -.0025 | -.0313 | -.0597 | -.0591 | -.0253 | -- |
|           | 1      | 2      | 3      | 4      | 5      | 6      | 7      | 8      | 9      | 10 |